



# Safety Effects of Flashing Yellow Arrow



# Presentation Overview

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- Background – What is FYA?
- National Safety Research
- North Carolina Sites
- North Carolina Crash Data Monitoring
- Summary

# Background

- NCHRP 493 (2003)
  - States use a variety of different permissive left turn displays

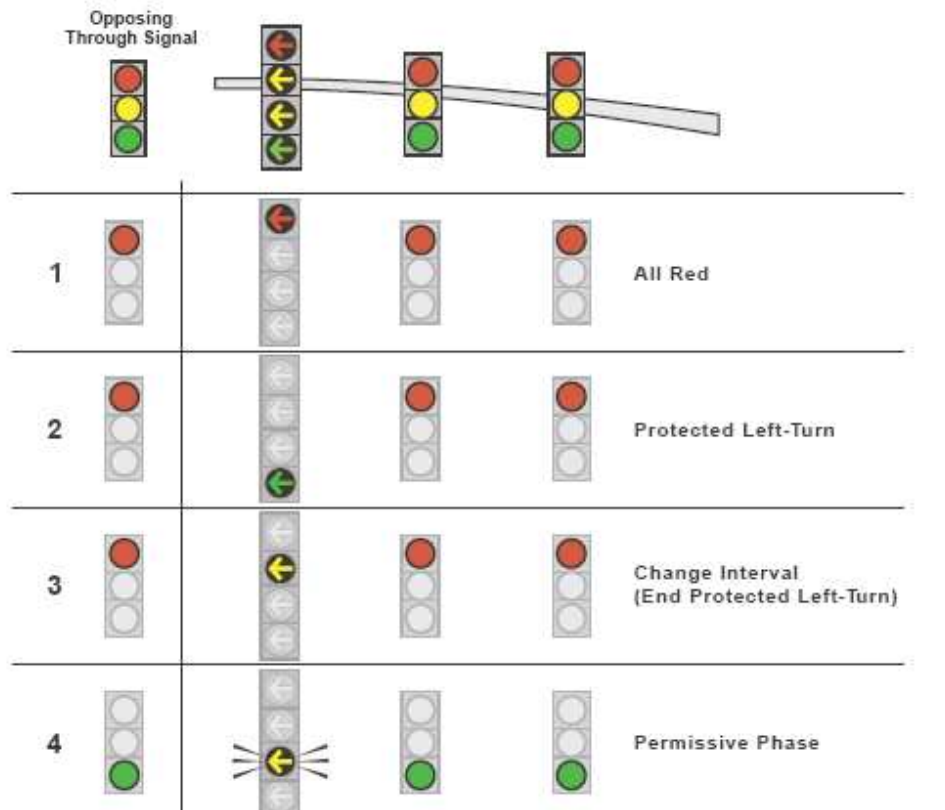
- Flashing circular yellow
- Flashing yellow arrow
- Flashing circular red
- Flashing red arrow
- Flashing green arrow
- Steady circular green

| Area Used                       | Lens Color and Arrangement | Left-Turn Indication |                |
|---------------------------------|----------------------------|----------------------|----------------|
|                                 |                            | Protected Mode       | Permitted Mode |
| Maryland                        |                            |                      |                |
| Michigan                        |                            |                      |                |
| Washington State                |                            |                      |                |
| NO LONGER IN OPERATION          |                            |                      |                |
| Delaware                        |                            |                      |                |
| Seattle, WA                     |                            |                      |                |
| * Green or Yellow Bi-modal Lens |                            |                      |                |
| Sparks, NV                      |                            |                      |                |
| Cupertino, CA                   |                            |                      |                |
| Reno, NV                        |                            |                      |                |

- Recommended flashing yellow arrow display
  - Best understood in driver simulation and still photograph studies

# Background

- How does it work?



- Benefits

- Operational

- Flexibility

- Only permissive

- Only protected

- Lead lag optimization

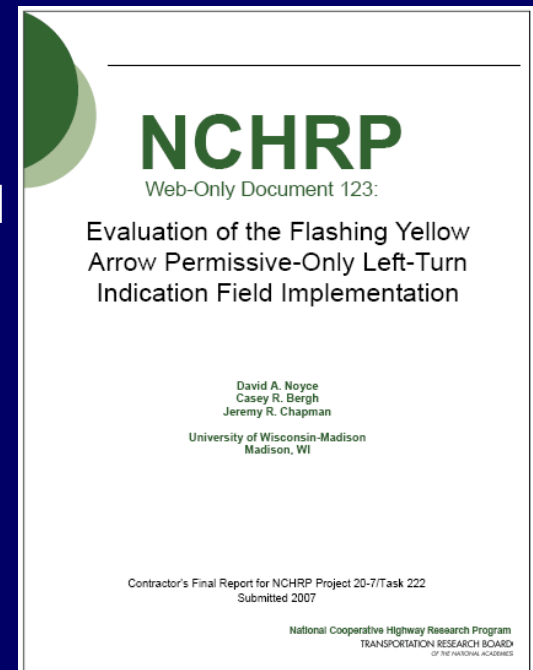
- Yellow trap

- Safety

- Better understood in simulation = safer?

# National Safety Research

- NCHRP Web Doc 123 (2007)
  - Looked at all National Installations
    - 104 sites total
    - 50 sites that had enough crash data
  - 3 General Findings
    - Protected / Permitted => FYA Protected / Permitted
      - Safety Improved
    - Protected only => FYA Protected / Permitted
      - Safety Not Improved
    - Permissive only => FYA Protected / Permitted
      - Inconclusive (not enough data)

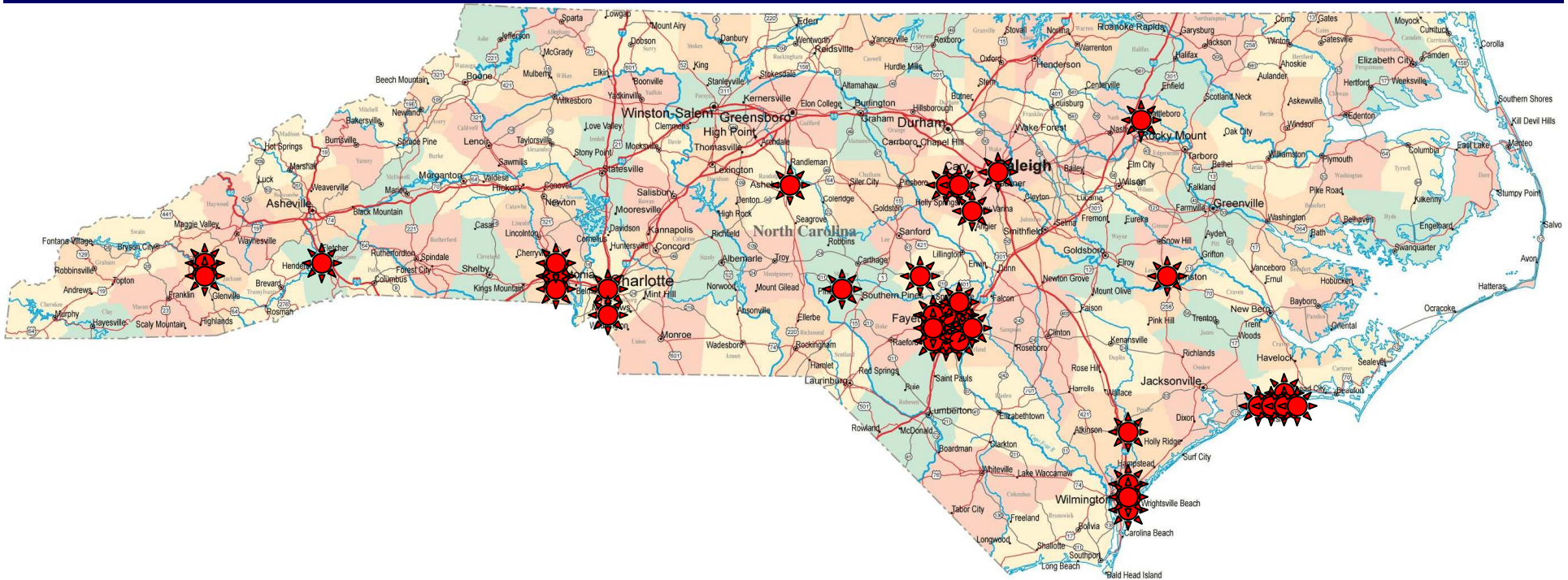




# North Carolina Installations

- Installations by year

| Year                | Number of FYA Installations |
|---------------------|-----------------------------|
| 2004                | 1                           |
| 2005                | 2                           |
| 2006                | 6                           |
| 2007                | 12                          |
| Through August 2008 | 15                          |
| Total               | 36                          |



# North Carolina Crash Data Monitoring

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- Initially, FHWA requirement that these sites are monitored
- All sites are monitored quarterly up to 1 year after installation
  - After one year, sites are monitored yearly
- Currently monitoring 22 sites

# Evaluation Challenges

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- Relatively new device
  - Few sites
  - Little 'after' data
- Other changes made to signal at time of FYA installation
  - Timing changes, other signal head upgrades, turn lanes, new developments, etc...
  - Difficult to single out effect of FYA
- Naïve before and after



# **Example Before and After Analyses**

# SR 2911 (New Bern Ave) at Wake Med Visitor Entrance

- Installed February 2005



# SR 2911 (New Bern Ave) at Wake Med Visitor Entrance

Looking Westbound

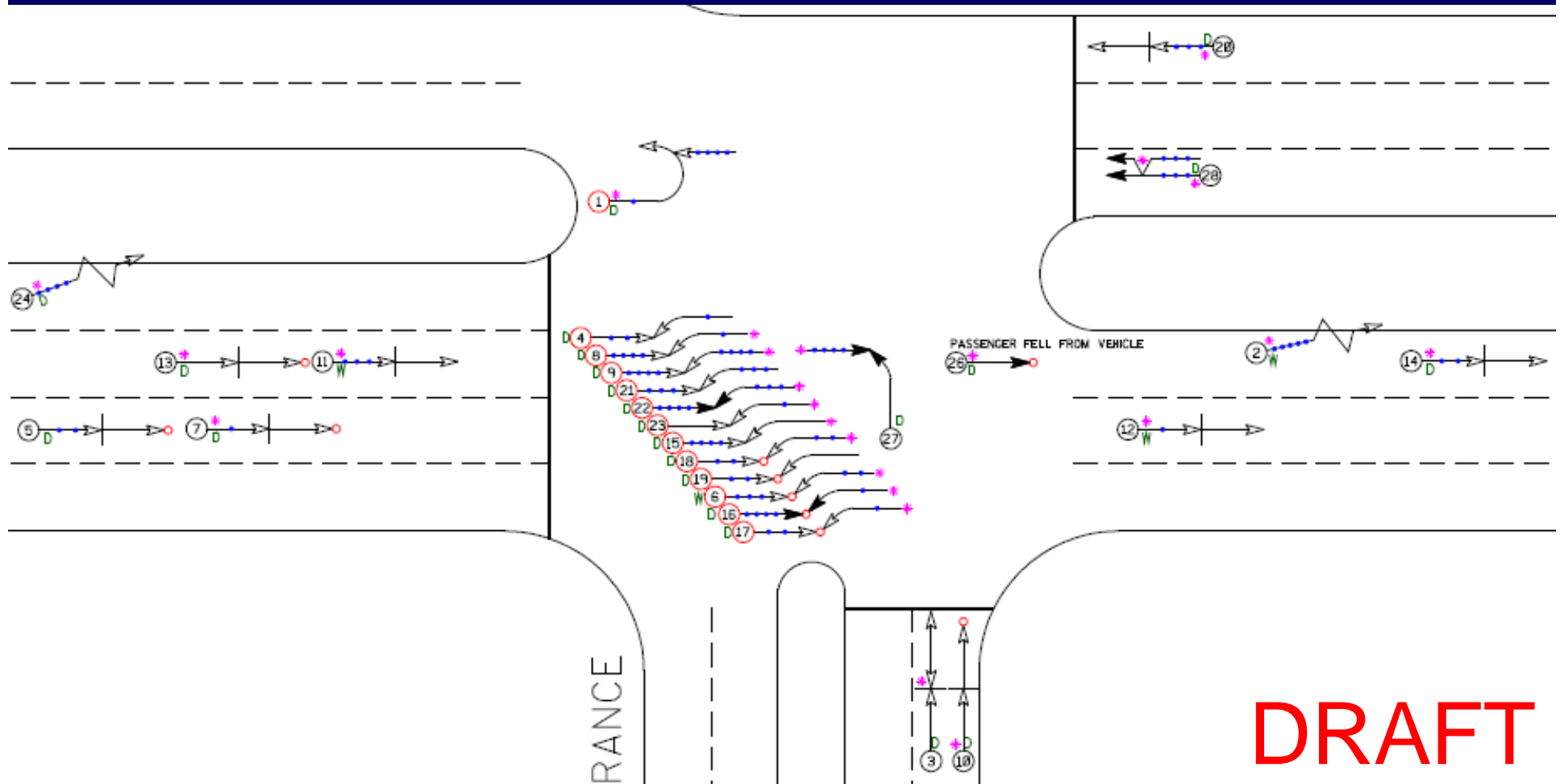


Looking Eastbound



# SR 2911 (New Bern Ave) at Wake Med Visitor Entrance

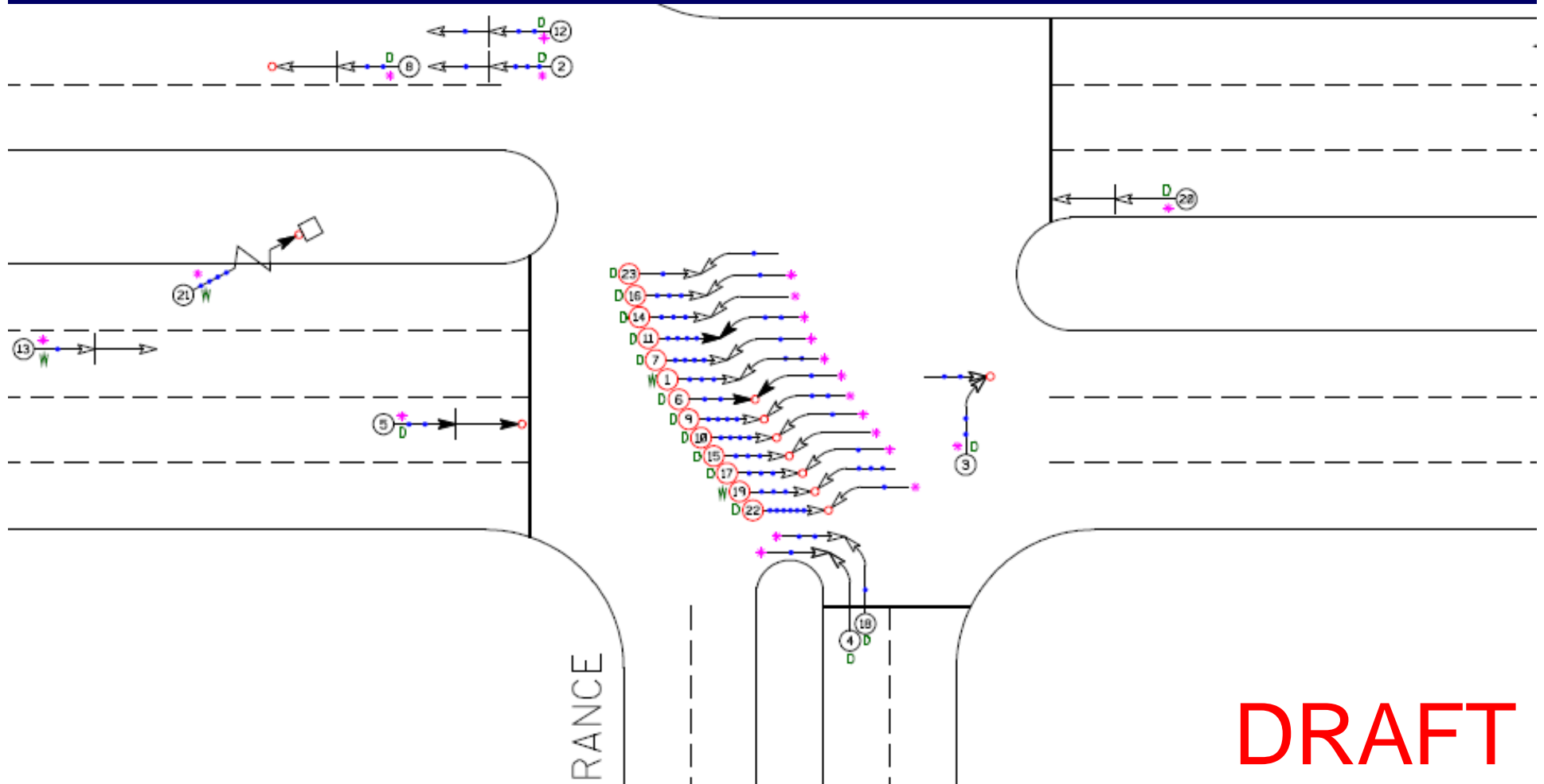
Before period – 3 years





# SR 2911 (New Bern Ave) at Wake Med Visitor Entrance

After period – 3 years



# SR 2911 (New Bern Ave) at Wake Med Visitor Entrance

## Before and After Summary

| <u>Treatment Information</u> | Before<br>3 Year | After<br>3 Year | Percent Reduction (-)/<br>Percent Increase (+) |
|------------------------------|------------------|-----------------|--|
| Total Crashes                | 28               | 23              | -17.9%   |
| Total Severity Index         | 3.64             | 4.54            | 24.7%  |
|                              |                  |                 |  |
| Target Crashes               | 13               | 13              | 0.0%   |
| Target Severity Index        | 3.85             | 4.98            | 29.4%  |

| <u>Target Crash Information</u> | Before<br>3 Year | After<br>3 Year | Percent Reduction (-)/<br>Percent Increase (+) |
|---------------------------------|------------------|-----------------|--|
| Fatal Injury Crashes            | 0                | 0               | --   |
| Non-Fatal Injury Crashes        | 5                | 7               | 40.0%  |
| Total Injury Crashes            | 5                | 7               | 40.0%  |
| Night Crashes                   | 2                | 2               | 0.0%   |
| Wet Crashes                     | 1                | 2               | 100.0%   |

**DRAFT**



# US 117 / NC 132 (College) at K-Mart Entrance

- Installed November 2005





# US 117 / NC 132 (College) at K-Mart Entrance

## Looking Northbound

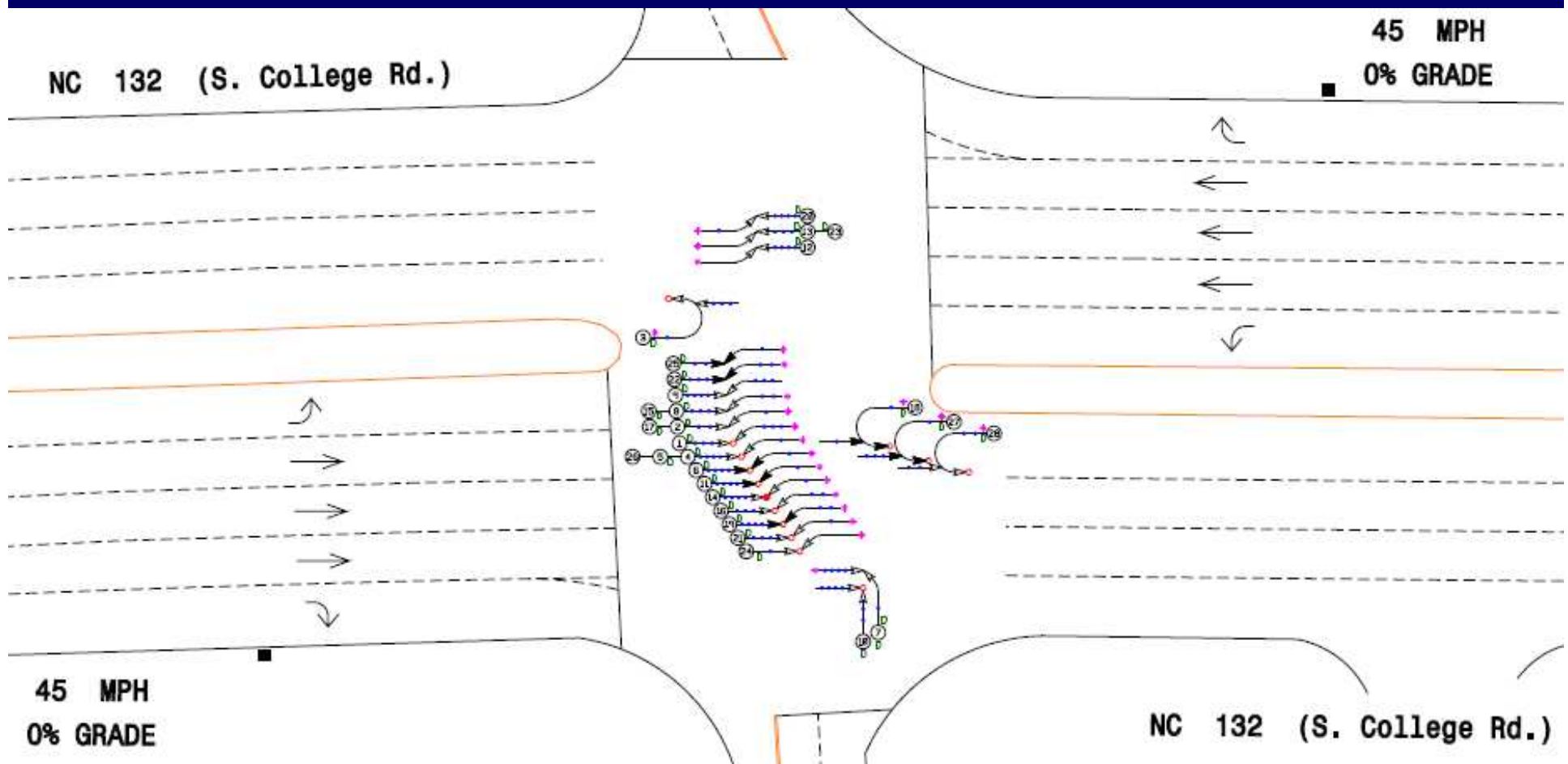


## Looking Southbound



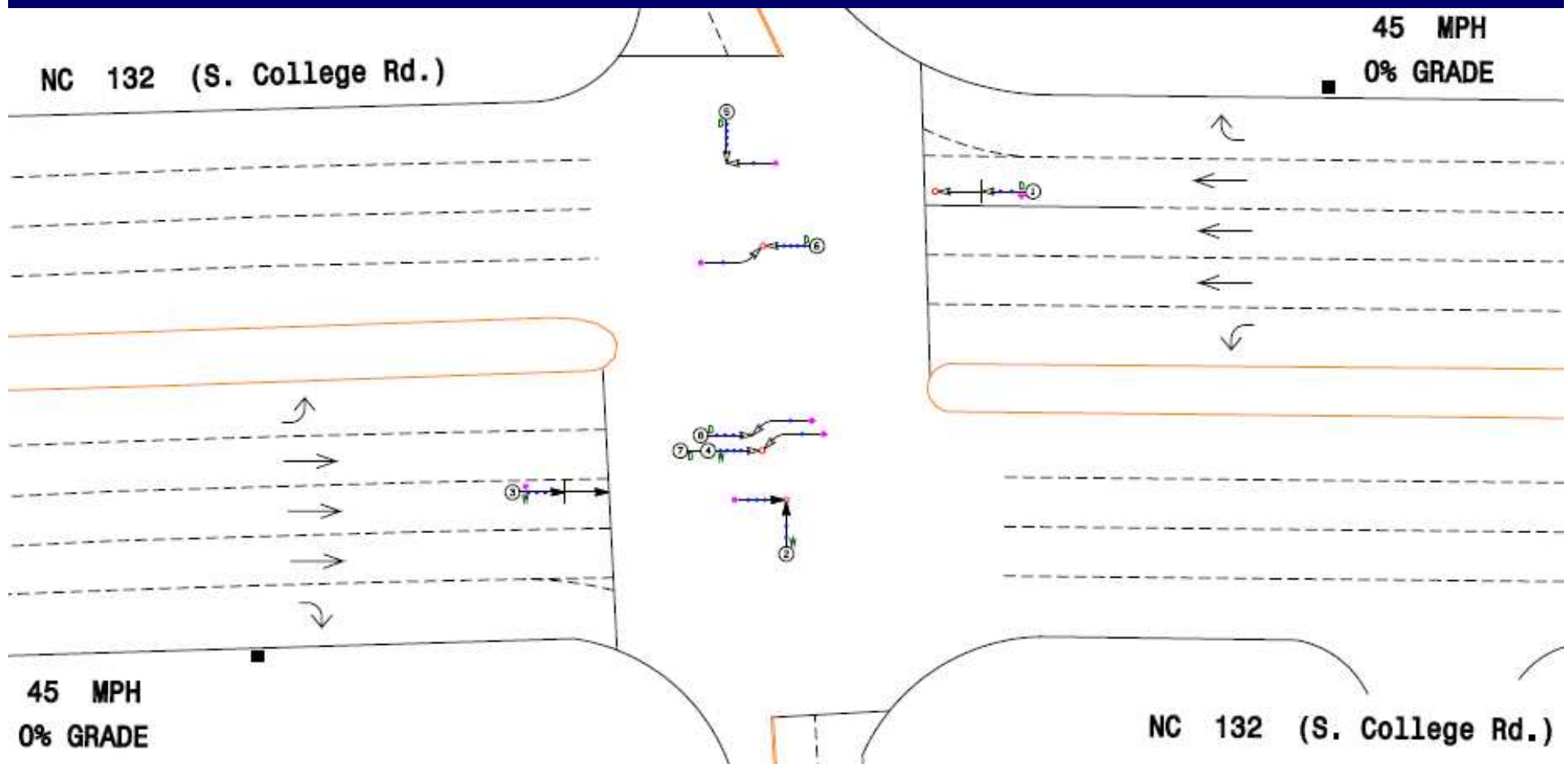
# US 117 / NC 132 (College) at K-Mart Entrance

Before period – 3 years



# US 117 / NC 132 (College) at K-Mart Entrance

After period – 1 year



# US 117 / NC 132 (College) at K-Mart Entrance

## Before and After Summary

| <u>Treatment Information</u> | Before |          | After  | Percent Reduction (-)/<br>Percent Increase (+) |
|------------------------------|--------|----------|--------|--|
|                              | 3 Year | Per Year | 1 Year |  |
| Total Crashes                | 28     | 9.3      | 8      | -14.3%   |
| Total Severity Index         | 9.85   |          | 5.62   | -42.9%   |
|                              |        |          |        |  |
| Target Crashes               | 26     | 8.7      | 4      | -53.8%   |
| Target Crashes               | 10.25  |          | 6.55   | -36.1%   |

| <u>Target Crash Information</u> | Before |          | After  | Percent Reduction (-)/<br>Percent Increase (+) |
|---------------------------------|--------|----------|--------|--|
|                                 | 3 Year | Per Year | 1 Year |  |
| Fatal Injury Crashes            | 1      | 0.3      | 0      | -100.0%  |
| Non-Fatal Injury Crashes        | 13     | 4.3      | 3      | -30.8%   |
| Total Injury Crashes            | 14     | 4.7      | 3      | -35.7%   |
| Night Crashes                   | 7      | 2.3      | 0      | -100.0%  |
| Wet Crashes                     | 0      | 0.0      | 1      | 100.0%   |

# Grouped Before and After Data



# PRELIMINARY

## Before and After Crash Summary

*Category 1: Permissive Only to FYA Protected-Permitted*

Detailed Before After

Permissive Only to FYA Protected-Permitted

| Div                                    | County   | Location   | Installation Date | Before    |                        |                         | After     |                        |                         | Naïve Before and After |                |
|--|----------|--|-------------------|-----------|------------------------|-------------------------|-----------|------------------------|-------------------------|------------------------|----------------|
|  |          |  |                   | No. Years | Total Crashes Per Year | Target Crashes Per Year | No. Years | Total Crashes Per Year | Target Crashes Per Year | Total Crashes          | Target Crashes |
| 14                                     | Jackson  | NC 107 at SR 1723 (Jones) / Bryson Farm Supply Ent | 2/14/2008         | 0.25      | 12.04                  | 4.01                    | 0.25      | 12.04                  | 0.00                    | 0%                     | 100%           |
| 8                                      | Randolph | US 64 / NC 49 at SR 2221 (Loflin Pond)             | 2/25/2008         | 3.00      | 4.01                   | 0.00                    | 0.25      | 4.01                   | 0.00                    | 0%                     | --             |
| Totals                                 |          |  |                   | 3.24      | 16                     | 4                       | 0.50      | 16                     | 0                       | 0%                     | 100%           |
| Totals (At Least 1 Year of After Data) |          |  |                   | No Data   |                        |                         |           |                        |                         |                        |                |

## Grouped Before After Reductions

|                           | Before | After | Percent Reduction (-)/<br>Percent Increase (+) |
|---------------------------|--------|-------|--|
| Total Crashes (Per Year)  | 16     | 16    | 0%   |
| Target Crashes (Per Year) | 4      | 0     | -100%  |

Very Little 'After' Period Data

# PRELIMINARY

## Before and After Crash Summary

*Category 2: Protected Only to FYA Protected-Permitted*

Detailed Before After

Protected Only to FYA Protected-Permitted

| Div                                    | County     | Location  | Installation Date | Before    |                        |                         | After     |                        |                         | Naïve Before and After |                |
|--|------------|---|-------------------|-----------|------------------------|-------------------------|-----------|------------------------|-------------------------|------------------------|----------------|
|  |            |   |                   | No. Years | Total Crashes Per Year | Target Crashes Per Year | No. Years | Total Crashes Per Year | Target Crashes Per Year | Total Crashes          | Target Crashes |
| 6                                      | Cumberland | US 401 Business (Raeford) at Brighton           | 11/14/2006        | 3.00      | 15.01                  | 0.33                    | 1.00      | 19.07                  | 4.01                    | -27%                   | -1103%         |
| 6                                      | Cumberland | US 401 Business (Raeford) at Fairfield          | 11/14/2006        | 3.00      | 6.00                   | 0.33                    | 1.00      | 8.03                   | 3.01                    | -34%                   | -802%          |
| 6                                      | Cumberland | US 401 Business (Raeford) at Montclair          | 11/14/2006        | 3.00      | 7.34                   | 0.00                    | 1.00      | 9.03                   | 0.00                    | -23%                   | --             |
| 6                                      | Cumberland | US 401 Business (Raeford) at Purdue             | 11/14/2006        | 3.00      | 9.34                   | 0.33                    | 1.00      | 13.04                  | 4.01                    | -40%                   | -1103%         |
| 14                                     | Jackson    | NC 107 at SR 1330 (Country Club / Forest Hills) | 7/20/2007         | 3.00      | 2.67                   | 0.33                    | 0.75      | 4.01                   | 1.34                    | -50%                   | -301%          |
| Totals                                 |            |   |                   | 14.99     | 40                     | 1                       | 4.73      | 53                     | 12                      | -32%                   | -827%          |
| Totals (At Least 1 Year of After Data) |            |   |                   | 14.99     | 37.69                  | 1.00                    | 4.73      | 49.17                  | 11.04                   | -30%                   | -1003%         |

Grouped Before After Reductions

|                           | Before | After | Percent Reduction (-)/<br>Percent Increase (+) |
|---------------------------|--------|-------|--|
| Total Crashes (Per Year)  | 40     | 53    | 32%  |
| Target Crashes (Per Year) | 1      | 12    | 827%   |

Significant Increase

# PRELIMINARY

## Before and After Crash Summary

### Category 3: "Doghouse" Protected-Permitted to FYA Protected-Permitted

Detailed Before After

5 Section "Doghouse" Protected-Permitted to FYA Protected-Permitted

| Div                                    | County      | Location  | Installation Date | Before    |                        |                         | After     |                        |                         | Naïve Before and After |                |
|--|-------------|---|-------------------|-----------|------------------------|-------------------------|-----------|------------------------|-------------------------|------------------------|----------------|
|  |             |   |                   | No. Years | Total Crashes Per Year | Target Crashes Per Year | No. Years | Total Crashes Per Year | Target Crashes Per Year | Total Crashes          | Target Crashes |
| 2                                      | Carteret    | NC 58 (Emerald) at Bogue Inlet                      | 5/22/2007         | 3.00      | 2.67                   | 0.00                    | 1.00      | 3.00                   | 0.00                    | -12%                   | --             |
| 2                                      | Carteret    | NC 58 (Emerald) at Coast Guard                      | 5/21/2007         | 3.00      | 3.00                   | 0.67                    | 1.00      | 2.00                   | 0.00                    | 33%                    | 100%           |
| 2                                      | Carteret    | NC 58 (Emerald) at Loon / Emerald Plantation        | 5/21/2007         | 3.00      | 3.00                   | 0.00                    | 1.00      | 7.00                   | 0.00                    | -133%                  | --             |
| 2                                      | Carteret    | NC 58 (Emerald) at Mangrove                         | 5/22/2007         | 3.00      | 5.34                   | 0.00                    | 0.75      | 6.69                   | 1.34                    | -25%                   | --             |
| 8                                      | Chatham     | US 64 at NC 751/SR 1001                             | 5/8/2007          | 3.00      | 13.02                  | 4.67                    | 1.00      | 6.00                   | 3.00                    | 54%                    | 36%            |
| 6                                      | Harnett     | NC 87 at SR 1115 (Buffalo Lake)                     | 02/2006           | 3.00      | 5.67                   | 3.00                    | 2.00      | 5.00                   | 2.50                    | 12%                    | 17%            |
| 2                                      | Lenoir      | US 258 at SR 1001 (Paul's Path)/SR 1557 (Hull)      | 7/16/2007         | 3.00      | 11.69                  | 5.01                    | 0.75      | 13.38                  | 1.34                    | -14%                   | 73%            |
| 10                                     | Mecklenburg | SR 3300 (7th) at 5th / Firefighter                  | 11/6/2007         | 3.00      | 4.34                   | 1.00                    | 0.50      | 2.01                   | 0.00                    | 54%                    | 100%           |
| 8                                      | Moore       | NC 5 at SR 1205 (Morganton) / Golf Terrace Entrance | 10/12/2006        | 3.00      | 3.00                   | 1.00                    | 1.49      | 6.02                   | 2.01                    | -101%                  | -101%          |
| 3                                      | New Hanover | NC 132 (College) at Hollytree                       | 1/3/2007          | 3.00      | 13.01                  | 4.34                    | 1.00      | 8.03                   | 1.00                    | 38%                    | 77%            |
| 3                                      | New Hanover | NC 132 (College) at K-Mart PVA                      | 11/2005           | 3.00      | 9.34                   | 8.67                    | 2.00      | 7.52                   | 5.01                    | 20%                    | 42%            |
| 5                                      | Wake        | SR 2911 (New Bern) at Wake Med Visitor Entrance     | 02/2005           | 3.00      | 9.34                   | 4.34                    | 3.00      | 7.68                   | 4.34                    | 18%                    | 0%             |
| Totals                                 |             |   |                   | 35.96     | 83                     | 33                      | 15.47     | 74                     | 21                      | 11%                    | 37%            |
| Totals (At Least 1 Year of After Data) |             |   |                   | 35.96     | 62.06                  | 26.69                   | 15.47     | 52.25                  | 17.86                   | 16%                    | 33%            |

### Grouped Before After Reductions

|                           | Before | After | Percent Reduction (-)/<br>Percent Increase (+) |
|---------------------------|--------|-------|--|
| Total Crashes (Per Year)  | 83     | 74    | -11%   |
| Target Crashes (Per Year) | 33     | 21    | -36%   |

# PRELIMINARY

## Before and After Crash Summary

### *All Categories Summarized*

#### Category 1: Permissive Only to FYA Protected-Permitted

|                           | Before | After | Percent Reduction (-)/<br>Percent Increase (+) |
|---------------------------|--------|-------|--|
| Total Crashes (Per Year)  | 16     | 16    | 0%   |
| Target Crashes (Per Year) | 4      | 0     | -100%  |

#### Category 2: Protected Only to FYA Protected-Permitted

|                           | Before | After | Percent Reduction (-)/<br>Percent Increase (+) |
|---------------------------|--------|-------|--|
| Total Crashes (Per Year)  | 40     | 53    | 32%  |
| Target Crashes (Per Year) | 1      | 12    | 827%   |

#### Category 3: 5 Section "Doghouse" Protected-Permitted to FYA Protected-Permitted

|                           | Before | After | Percent Reduction (-)/<br>Percent Increase (+) |
|---------------------------|--------|-------|--|
| Total Crashes (Per Year)  | 83     | 74    | -11%   |
| Target Crashes (Per Year) | 33     | 21    | -36%   |

# Key Points / Summary

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- Still not enough data to make conclusive safety statements
- Preliminary results seem promising
  - Likely will not see large crash reductions
  - Large increase in crashes at sites that went from protected to FYA protected-permitted likely due to phasing change and not FYA itself
- TSU will continue to monitor and provide feedback

# Contact Information

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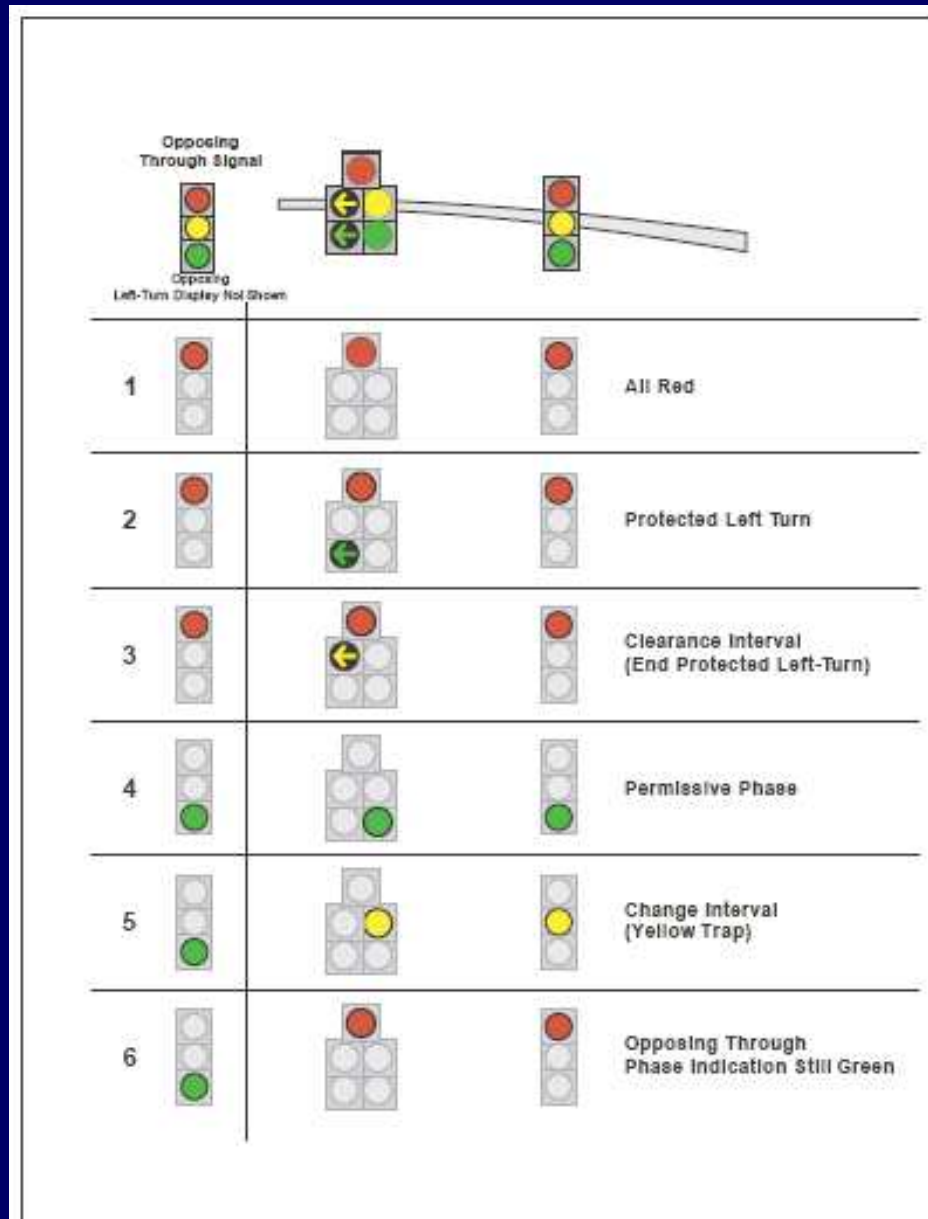


**Traffic Safety Unit Website:**

<http://www.ncdot.org/doh/preconstruct/traffic/TSU/default.html>



# Yellow Trap Slide



# Sources

- Slides 3,4 – NCHRP 493
- Slides 5 – NCHRP Web only 123

